Experiment 1: What is a Calorie?

EQUIPMENT NEEDED:

— Calorimeter
— Balance
— Thermometer
— Hot and cold water

Introduction

When two systems or objects of different temperature come into contact, energy in the form of heat is transferred from the warmer system into the cooler. This transfer of heat raises the temperature of the cooler system and lowers the temperature of the warmer system. Eventually the two systems reach some common, intermediate temperature, and the heat transfer stops.

The standard unit for measuring heat transfer is the calorie. A calorie is defined as the amount of energy required to raise the temperature of one gram of water from 14.5°C to 15.5°C. However, for our purposes, we can generalize this definition by simply saying that a calorie is the amount of energy required to raise the temperature of one gram of water one degree Celsius (the variation with temperature is slight).

In this experiment, you will combine hot and cold water of known temperature and mass. Using the definition of the calorie, you will be able to determine the amount of heat energy that is transferred in bringing the hot and cold water to their final common temperature, and thereby determine if heat energy is conserved in this process.

Procedure

① Determine the mass of the empty calorimeter, M_{cal}. Record your result in Table 1.1 on the following page.

② Fill the calorimeter about 1/3 full with cold water. Weigh the calorimeter and water together to determine $M_{cal + H_2O}$, cold. Record your result.

③ Fill a second calorimeter approximately 1/3 full of hot water. The water should be at least 20°C above room temperature. Weigh the calorimeter and water together to determine $M_{cal + H_2O}$, hot. Record your result

④ Measure T_{hot} and T_{cold}, the temperatures in degrees Celsius of the hot and cold water, and record your results.

⑤ Immediately after measuring the temperatures, add the hot water to the cold and stir with the thermometer until the temperature stabilizes. Record the final temperature of the mixture, T_{final}.

⑥ Repeat the experiment twice with different masses of water at different temperatures. (You might try adding cold water to hot instead of hot to cold.)

Data

Table 1.1 Data

	Trial 1	Trial 2	Trial 3
M_{cal}			
$M_{cal + H_2O,\ cold}$			
$M_{cal + H_2O,\ hot}$			
T_{hot}			
T_{cold}			
T_{final}			
M_{final}			

Calculations

From your data, make the calculations necessary to determine the mass of the hot and cold water that were combined, and also the temperature changes (ΔT) undergone by each. Enter your results in Table 1.2.

Using the equations shown below, calculate ΔH_{cold} and ΔH_{hot}, the heat gained by the cold and hot water, respectively. Enter your results in the table.

$$\mathbf{\Delta H_{cold} = (M_{H_2O,\ cold})\ (\Delta T_{cold})\ (1\ cal/gm^{\circ}C)};\quad \mathbf{\Delta H_{hot} = (M_{H_2O,\ hot})\ (\Delta T_{hot})\ (1\ cal/gm^{\circ}C}$$

Table 1.2 Calculations

	Trial 1	Trial 2	Trial 3
$M_{H_2O,\ cold}$			
$M_{H_2O,\ hot}$			
ΔT_{hot}			
ΔT_{cold}			
ΔH_{cold}			
ΔH_{hot}			

Questions

① Which had more thermal energy, the two cups of water before they were mixed together or after they were mixed? Was energy conserved?

② Discuss any unwanted sources of heat loss or gain that might have had an effect on the experiment.

③ If 200 grams of water at 85°C were added to 150 grams of water at 15°C, what would be the final equilibrium temperature of the mixture?